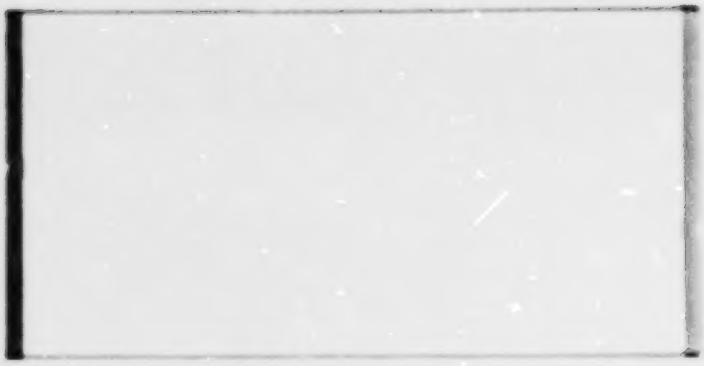
Ontario Hydro



RESEARCH DIVISION

91602
new 82-10

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part.

ontario hydro
research division

EFFECTIVENESS OF A HIDROSTAL PUMP IN THE LIVE TRANSFER OF AMERICAN EELS

Report No. 84-150-K

P.H PATRICK
Research Biologist
Chemical Research Department

ABSTRACT

The effectiveness of a Hidrostal pump in the live transfer of American eels (Anguilla americana) was investigated under laboratory conditions. Eel survival 72h after passage through the pump was high, averaging approximately 98% over all test conditions. Eel mortality in the experimental tests was not significantly different from that observed in the controls. There was no significant increase in mortality observed with either an increase in pump impeller speed (890-1204 rpm) or eel density (low-high). The Hidrostal pump shows promise for application at Saunders GS in the passage of American eels.

job	file	date	report no.
740634-139-392	837.315	May 22, 1984	84-150-K

Table of Contents

	Page
INTRODUCTION	1
MATERIALS AND METHODS	1
Test animals	1
Fish pump and transport system	1
Experimental design	2
Statistical analysis	4
RESULTS AND DISCUSSION	4
Behavioural observations	4
Fish survival	4
SUMMARY	6
REFERENCES	7
APPENDIX A	8
DISTRIBUTION	last page

LIST OF FIGURES

	Page
1. General layout of Hidrostal pump and transport system	3

LIST OF TABLES

	Page
1. Experimental design	4
2. Effectiveness of a Hidrostal pump in the live transfer of American eels (*Anguilla americana*)	5

91601
new 82-10

ontario hydro
research division

To R.A.Wright
Manager,
Hydraulic Plant Equipment

EFFECTIVENESS OF A HIDROSTAL PUMP IN THE LIVE TRANSFER OF AMERICAN EELS

INTRODUCTION

Migrating American eels (Anguilla americana) have caused serious operational problems at the R.H. Saunders Hydro-Electric Power Dam on the St. Lawrence River at Cornwall, Ontario. When the upper flow control gate of a unit is closed, resulting in a gradually reduced current flow, large numbers of eels swim into the turbine housing before the lower control gates can be lowered. The large number of eels present in the turbine clog the pump intakes preventing unit dewatering. One possible solution to alleviate this problem is to pump eels back into the river system via a fish pump before the unit is dewatered. A review of the literature on fish pumps suggested that a Hidrostal pump shows promise as a fish pump (Des.& Dev. Report No. 79009), and may be applicable at Saunders G.S. A Hidrostal pump has been shown to effectively pass without harm several Great Lakes species (O.H.R.D.R. 82-295-K, Holsapple et al. 1981). At the request of the Hydraulic Plant Equipment Department (Our File 837.315), a study was undertaken to determine the effectiveness of the Hidrostal pump in the live transfer of American eels.

MATERIALS AND METHODS

Test animals

Yellow American eels (Anguilla americana), 30-50cm in length, were netted in late September 1983 at the R.H. Saunders dam, held in 2.5m circular diameter tanks under a controlled natural photoperiod, and fed earthworms. Water temperature in the tanks varied from 9-13°C.

Fish pump and transport system

The Hidrostal fish pump (model H5F) used in these tests is designed for free passage of solid objects up to approximately 10 cm diameter. The pump consists of a screw-type impeller, and

was operated by a 10 hp (249 V) motor with a variable speed drive control that provided impeller speeds from 400 to 1200 rpm (revolutions per minute).

Tests were conducted in a square concrete tank (6m x 6m) with a depth of approximately 1.2m (Figure 1). Although the pump itself was located outside the test tank, both intake and discharge pipes were positioned inside the tank. The intake and discharge pipes were 15 and 25 cm in diameter, which resulted in water velocities of approximately 4.4 and 1.6 m/s, respectively, at impeller speeds over 1000 rpm. These intake velocities are probably higher than those expected at Saunders G.S. The entire transport system was approximately 10 m in length, with a calculated head of approximately 3.2 m. Both intake and discharge pipes included a transparent (acrylic) 1.0 m section which allowed viewing of fish as they were transported through the loop.

In mortality tests, fish were placed in a pipe system which fed into the pump intake. This pipe was necessary since eels actively avoided the intake mouth. A more detailed discussion of eel avoidance of the intake area is given in the Results and Discussion section. A screened cage (approximately 2 cm square mesh) was placed around the pump discharge to restrict fish to this area.

Experimental design

The effectiveness of the Hidrostal pump in the live transfer of American eels was evaluated relative to impeller speed and fish density (Table 1). Pump speeds of 890, 1043, and 1204 rpm were used in the design which are within the range of impeller speeds proposed for use at Saunders G.S. Eels were pumped at four densities which ranged from approximately 13 to 85 fish per 100 L of water. At the highest density it was expected that we were approaching near the capacity of the pump in the passage of solids in an aqueous environment (ie 40% solid, 60% liquid).

Eel survival was determined immediately following pump passage (time 0 h), and at times 24, 48 and 72 h. At each interval, eels were examined for external injury. Five replicates were conducted at each pump speed (890, 1043, 1204 rpm) for both low and medium eel densities (13, 26 animals/ 100 L), for a total of 30 tests (Table 1). Four replicates were conducted for tests employing an eel density of 43 animals/ 100 L (high density) at a pump speed of 1043 rpm. One test was conducted using approximately 85 animals/ 100L at a pump speed of 1043 rpm. During each experimental test, fish were held in containers (two) to determine natural eel mortality due to handling over a 72 h period. These controls were conducted concurrently with the experimental tests. Mortality of controls was less than 7% in all tests with an average mortality of less than 2%. Fish survival in each experimental test following passage through the pump was estimated relative to fish survival in corresponding controls for each time interval.

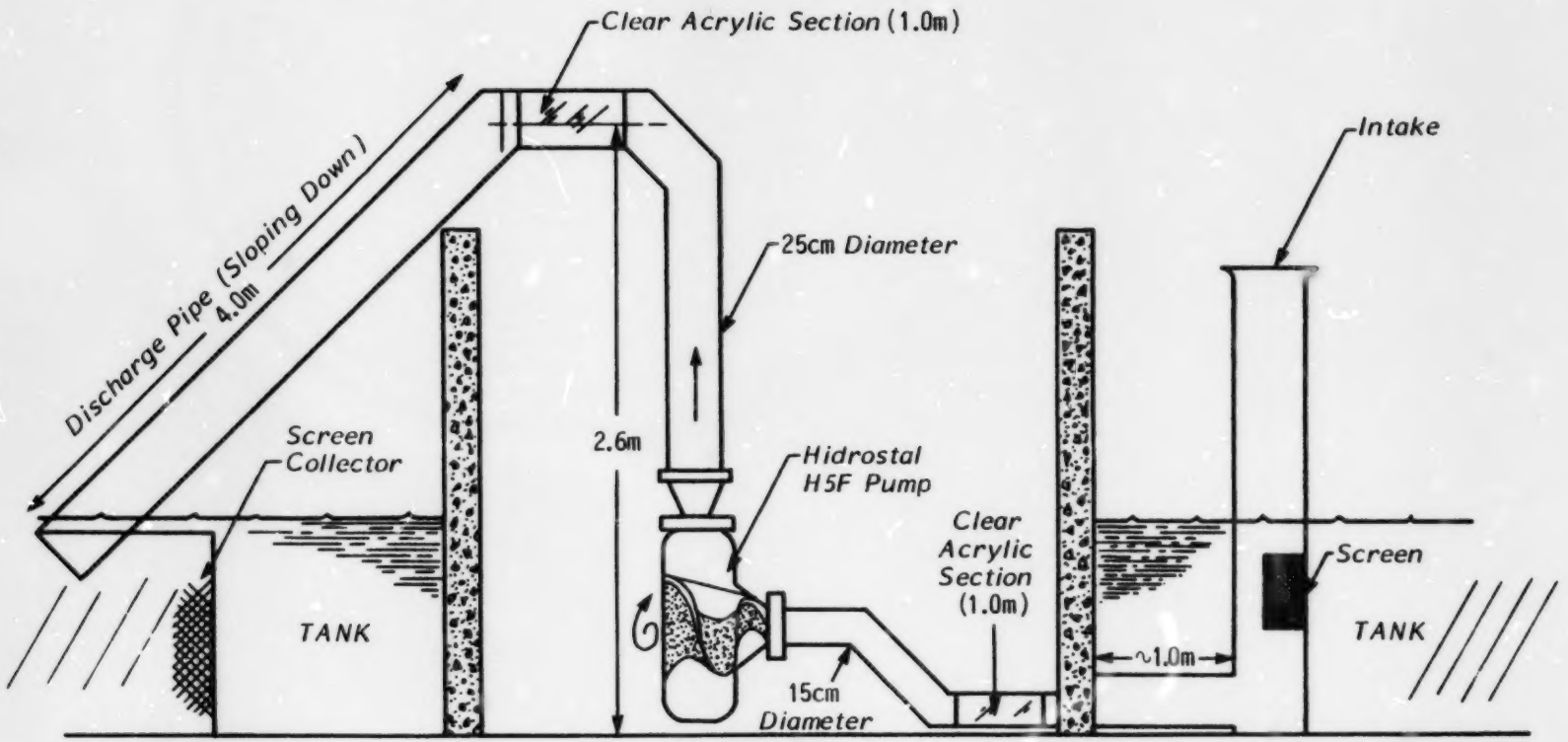


FIGURE 1

GENERAL LAYOUT OF HIDROSTAL PUMP AND TRANSPORT SYSTEM

Table 1
Experimental design

Pump Speed (rpm)	No. Eels/Test	Approximate Eel Density (No. Eels/ 100L)
890	15	13
	30	26
1043	15	13
	30	26
1204	15	13
	30	26
1043	50	43
1043	100	85

Statistical analysis

Survival data (in percent) were analyzed using analysis of variance. Data were arc sign transformed prior to analysis.

RESULTS AND DISCUSSION

Behavioural observations

An obvious fish avoidance of the intake area was observed during pumping, irrespective of impeller speed. It was not known whether eels avoided this area because of the noise created by the pump or simply avoided the high current flows near the intake mouth. Casual observation indicated that eels that were swept by net towards the intake entrance could not maintain position in the high currents (>1.0 m/s), and were drawn into the pump.

Fish survival

A total of 925 eels were passed through the pump system at different impeller speeds and eel densities (Table 2). Overall, eel survival over a 72 h period was excellent, averaging approximately 98% over all test conditions. For all test conditions, there was no significant difference in mortality between controls and experimentals ($F_{1,46} = 0.1, p > 0.05$). No mortality was ever observed on animals immediately following

TABLE 2

EFFECTIVENESS OF A HIDROSTAL PUMP IN THE LIVE TRANSFER OF AMERICAN EELS (*Anguilla americana*)

Pump Speed (rpm)	No. Animals /Test	Approximate Density (No. animals/100 L)	Percent Survival following passage (x̄+S.D.(x)) 0 h	24 h	48 h	72 h	Percent Injury	Type of Injury
890	15	13	100±0	100±0	99.3±1.5	98.7±1.8	5	bruises
	30	26	100±0	100±0	100.0±0	97.3±3.7	5	bruises
1043	15	13	100±0	100±0	100.0±0	100.0±0	5	bruises
	30	26	100±0	100±0	100.0±0	100.0±0	5	bruises
1204	15	13	100±0	100±0	100.0±0	100.0±0	5	bruises
	30	26	100±0	100±0	100.0±0	98.0±1.8	5	bruises
1043	50	43	100±0	100±0	95.0±5.8	94.5±6.4	5	bruises
	100	85	100±0	100±0	100.0±0	100.0±0	5	bruises

passage. Test mortality was evident only after 24 h following passage; however, it generally averaged less than three per cent for all test conditions. The only exception was the high density test (43 eels/ 100L) where survival was 94.5%. Still, this mortality (5.5%) was not significantly different from that observed in the controls ($F_{1,4} = 0.2, p > 0.05$). There was no indication of latent mortality for eels held several weeks following passage through the pump for any test condition.

There was no evidence of an increase in mortality with either an increase in impeller speed (890-1204 rpm, $F_{2,24} = 3.0$, $p > 0.05$) or eel density (13-85 animals/ 100 L, $F_{1,24} = 2.8$ $p > 0.05$). Still, it is probable that eel densities expected at Saunders G.S. will be significantly higher than that tested under laboratory conditions.

In this laboratory investigation, pump impeller speeds and flow volumes simulated those proposed for Saunders G.S. Intake pump velocities actually exceeded those expected in the field. However, we were not able to simulate the projected head; the head in the laboratory model (3.2 m) was approximately an order of magnitude lower than that expected at Saunders G.S. Because of this head, eels would be subjected to significant pressures at Saunders G.S. The effect of pressure on eels is not well documented, and it is possible that eels pumped at these heads may suffer lethal decompression. This should be verified in the field.

SUMMARY

1.0 The effectiveness of the Hidrostal pump in the live transfer of American eels was evaluated in the laboratory. A total of 925 eels were passed through the pump with an average survival rate of approximately 98% over all test conditions. Eel mortality in the experimental tests was not significantly different from that observed in the controls.

2.0 There was no significant increase in eel mortality with either an increase in pump impeller speed (890-1204 rpm) or eel density (low- high).

3.0 The Hidrostal pump shows promise for application at Saunders G.S. in the passage of American eels. Field evaluation of the Hidrostal pump is recommended.

Approved:

D. Harrison
Manager
Chemical Research Dept

Submitted:

P.H. Patrick
Research Biologist
Biological Research Section

REFERENCES

1.0 Design and Development Report No. 79009. 1978. Fish pumps and extractors: a review. A.E. Christie.

2.0 Holsapple, J.G., Roberts, R., and Y.G. Mussalli 1981. Development of an angled fine/coarse mesh travelling screen demonstration facility. Proc. Workshop on Advanced Intake Technology. San Diego, California. April 22-24.

3.0 OHRDR No.82-295-K. Effectiveness of a Hidrostal pump and transport system in the live transfer of fish. P.H. Patrick. August 31, 1982.

APPENDIX A

MORTALITY OF AMERICAN EELS AFTER PASSAGE THROUGH A HIDROSTAL PUMP

Pump Speed (rpm)	No. Animals /Test	Replicate	Mortality Following Pump Passage			
			0 h	24 h	48 h	72 h
860	15	1	0	0	0	0
		2	0	0	0	1
		3	0	0	0	0
		4	0	0	0	0
		5	0	0	1	0
		Control	0	0	0	0
		Control	0	0	1	0
	30	1	0	0	0	0
		2	0	0	0	2
		3	0	0	0	0
		4	0	0	0	0
		5	0	0	0	0
		Control	0	0	0	0
		Control	0	0	0	0
1043	15	1	0	0	0	0
		2	0	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		5	0	0	0	0
		Control	0	0	0	0
		Control	0	0	0	0
	30	1	0	0	0	0
		2	0	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		5	0	0	0	0
		Control	0	0	0	0
		Control	0	0	0	0

APPENDIX A cont'd

Pump Speed (rpm)	No. Animals /Test	Replicate	Mortality Following Pump Passage			
			0 h	24 h	48 h	72 h
1204	15	1	0	0	0	0
		2	0	0	0	0
		3	0	0	0	0
		4	0	0	0	0
		5	0	0	0	0
		Control	0	0	0	0
		Control	0	0	0	0
	30	1	0	0	0	0
		2	0	0	0	1
		3	0	0	0	1
		4	0	0	0	1
		5	0	0	0	0
		Control	0	0	0	0
		Control	0	0	0	1
1043	50	1	0	0	0	0
		2	0	0	8	0
		3	0	0	1	0
		4	0	0	7	2
		Control	0	0	4	1
		Control	0	0	1	0
	100	1	0	0	0	0
		Control	0	0	0	0